I. C. 6881 APRIL 1936

DEPARTMENT OF THE INTERIOR

UNITED STATES BUREAU OF MINES
JOHN W. FINCH, DIRECTOR

INFORMATION CIRCULAR

TRENDS IN WHITE-PIGMENT CONSUMPTION

BY

PAUL M. TYLER

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INTRODUCTION

The expanding use of paint is a matter of common knowledge, and the utility of paint both to "save the surface" and for decorative purposes has become widely recognized. In 1914, according to the Bureau of Census, 585 establishments in the United States, were engaged in the manufacture of paint and pigments with an output valued at $112,409,000. In 1929 the number of establishments had increased to 1,063 and the value of products to $568,976,000. Lower prices and diminished consumption resulting from the world-wide depression reduced the output of the industry to around $300,000,000 in 1933, but even this reduced figure reflects only a relatively moderate decline compared with the almost complete collapse in building construction in this country.

This paper visualizes substantial expansion in the use of paint and consequently in the aggregate demand for paint materials, but with respect to products of the mining industry it calls attention to the rapid rise of titanium pigments, a sidewise or slightly upward trend for white lead, and a sidewise or possibly even a downward trend for certain zinc pigments, notably lithopone, which only a few years ago was by far the fastest growing member of the pigment family.

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DEMAND FOR PAINT

Painting as a decorative art dates from prehistoric times. Pigments were used in adorning the ancient temples of Luxor, and primitive peoples daubed themselves with bright-colored minerals. Linseed oil paints were used as early as the sixth century and before the end of the eighteenth century were considered quite important. In 1772 Mordecai Lewis, a member of the firm of Neave, Harman, & Lewis, was importing and dealing in white lead and red lead. This firm, later known as M. & S. N. Lewis, built a white lead factory in Philadelphia in 1820 and still later became the John T. Lewis & Bros. Co., which is now the Philadelphia Branch of the National Lead Co. As early as 1778, the firm of Samuel Wetherill & Sons was a large importer of chemical products including white lead and red lead and in 1804 erected the first white lead factory in the United States, in Philadelphia.3/ The use of paint for protective purposes, however, is a development of modern times; oil paints were not used extensively until well along in the nineteenth century. Oil paints were used for public buildings and for homes of some of the more prosperous, but most of the white houses of colonial times were covered with whitewash, ordinary lime suspended in water, rather than oil paint.

Fully 80 percent and probably a considerably larger proportion of American homes are still built of wood, and the number of those protected by weather-resisting paint films is growing steadily. Farmers over larger and larger areas of the United States have learned that even barns and outbuildings, if kept painted, will last enough longer to pay the cost of painting. Inasmuch as the publicity campaigns of paint makers and varnish-makers have made property owners conscious of the value of paint, the effective demand for exterior paints may be expected to increase even faster than that for other semidurable goods as the purchasing power of consumers recovers. New buildings are being erected, existing structures will be repainted, and many buildings that have never been painted and probably some that have been whitewashed henceforth will be treated with oil paint.

So much for exterior paints. More important still, however, in recent years has been the expanding use of interior paints. A market analysis would probably show that this trend reflects a change in styles of home decoration. A definite vogue in favor of painted walls was observed over a decade ago. Other wall coverings, including wall paper and cold-water paints, have been replaced by oil paints in private dwellings and even more extensively perhaps in apartments and offices where repeated changes in tenants call for frequent redecorating. The rapid growth in sales of interior paints coincided roughly with the boom in apartment building. On the other hand, the interior wall and ceiling surfaces of the average home are relatively much larger than the exterior surface; consequently, even for private dwellings the potential demand for interior paints is larger than that for exterior coatings. Although

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3/ These and other historical data in this paper are largely from a letter addressed to the author by R. L. Hallett.

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wear and tear of exterior paint films should be greater because of exposure to the weather, interior painting generally is done at more frequent intervals than outdoor painting. The paint on the inside walls may not deteriorate so rapidly, but an occupant will notice instantly any imperfections and the average American housewife may have a room repainted simply to achieve a different color scheme.

As affecting future demand, an unknown factor is the development of decorative structural materials, such as molded plastics, architectural tile, and glass products, which may reduce the surfaces requiring paint, both inside and out. Mention may be made, too, of the growing use of industrial paints, which are already sold in large volume.

PAINTS AND PIGMENTS

Ordinary paints contain essentially three components, the pigment, the vehicle or medium, and the drier or siccative. The most common vehicles are raw and boiled linseed oil. However, tung oil or china-wood oil is used in quite large quantities; other oils are poppy-seed, soya-bean, perilla, sunflower-seed, and menhaden. A paint vehicle of raw and boiled oils may be thinned with turpentine, petroleum spirits (mineral spirits), naphtha, or some of the new volatile solvents, or it may be a resin or gum varnish. All paints (except nitrocellulose lacquers and asphaltum paints) must contain a drying oil - such as linseed - a volatile thinner, and a small amount of drier. Enamels are virtually paints, the vehicle of which contains a substantial proportion of varnish. They formerly were made by grinding a pigment in a spirit varnish, but oil varnishes and various other vehicles are now employed. Enamel paints dry to give a characteristic glossy coat of great brilliance and light-reflecting value, but flat wall paints are essentially enamel paints. Lacquers usually contain nitrocellulose with suitable solvents. Varnishes, on the other hand, are not paints; they do not contain an opaque, insoluble pigment.

From the standpoint of the mining industries, the most important component of paints, enamels, or lacquers is the pigment (including "extenders"). Metallic salts are used as driers but in such small quantities as to afford no real tonnage outlet for mine products. Pigments may be defined as insoluble opaque powders that may yield paints when admixed with suitable media, thereby distinguishing them from dyes and stains which are soluble in the vehicles used. In addition to their use in the paint industry, pigments are consumed in the manufacture of rubber goods, linoleum, oilcloth, artificial leather, paper, printing inks, plastics, and textiles. The paint trade, however, affords the main market for pigments.

MATERIALS USED AS PIGMENTS

A favorable outlook for the paint trade should prove a source of satisfaction to the mining industry, but it does not follow that the producers of any particular item used in paintmaking will benefit by an anticipated expansion in sales of paint or the accompanying increase in the aggregate

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demand for pigments. A variety of substances, 215 or more, are used as pigments. The following list of the more important ones used for paint is modeled after a tabulation by Gardner[4]/

White Pigments

Lead pigments:
- White lead (corroded or basic carbonate of lead).
  - Old Dutch process.
  - Carter process.
  - Precipitation process.
  - Electrolytic process.
- Basic sulphate of lead (sublimed white lead).
- Leaded zinc oxide.

Zinc pigments:
- Zinc oxide (zinc white).
  - French process.
  - American process.
- Leaded zinc oxide.
- Lithopone (Beckton white, Albolith, Ponolith, Charlton white, Orr's white).
  - Ordinary (28 percent zinc sulphide).
  - High strength (50 percent zinc sulphide).
- Zinc sulphide.

Other opaque white pigments:
- Titanium oxide
- Titanium - barium pigments.
- Titanium - calcium pigments.
- Titanium - Silica pigments
- Titanated lithopone.

Silica pigments:
- Silica (Silex).
- Asbestine - Talcose.
- China clay - kaolin - Tolamite

Calcium pigments:
- Whiting, Paris white, chalk, Alba whiting, Spanish white.
- Gypsum, plaster of paris, Terra Alba, Agalite.

Barium pigments:
- Ground barytes (barite).
- Blanc fixe (precipitated barium sulphate).
- Barium carbonate (witherite).

Red and Brown Pigments

Red Lead - Orange mineral
Venetian red - Indian red - Tuscan red
Umbers - Siennas

4/ Gardner, H. A., Physical and Chemical Examination of Paints: Varnishes and Colors, Washington, D.C., 2d Ed., 1925, pp. 304-305.

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English Vermillion - American vermillion - Chinese scarlet
Organic red - Para red - Toluidine red

Blue Pigments

Blue basic lead sulphate
Ultramarine blue
Prussian blue - American blue - Antwerp blue - Chinese blue.

Yellow and Orange Pigments

Lemon chrome yellow - medium chrome yellow - Orange chrome yellow
Orange mineral.
Ochre

Green Pigments

Chrome green.
Chromium oxide.
Green earth.

Black Pigments

Graphite
Carbom black - bone black - lampblack - drop black - ivory black - mineral black.
Willow charcoal.
Black oxide of iron.

A good pigment must have hiding power and tinting strength, brightness and clearness of tone, permanence, inertness (that is, be unaffected by other pigments or the vehicle), good body, fineness, ease of manipulation, and suitable oil-absorption characteristics. Moreover, a paint film must not only resist disintegrating influences in the atmosphere and occasional mechanical wear on the outside but also must be blended so as to avoid destructive chemical action within itself. In addition to permanence and wear resistance, it must have both cohesive and adhesive properties. Some pigments seem to accelerate the oxidation action of the atmosphere on the surface of the oil, destroying its bonding power, with the result that the film gradually fails by dusting or "chalking." This is characteristic of white lead, and if the action does not proceed too rapidly a film of this sort may afford the best protection feasible under certain conditions. Other films, notably those carrying too much zinc oxide, are strongly cohesive but pull away from the surface and consequently flake off. Sundry other types of failure may occur, but the significant fact is that no single pigment is satisfactory in every respect. The consensus of opinion among the paint trade, based on long experience, is that a mixture of two or more pigments gives better results than any one pigment used alone.

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Many technicians distinguish between "pigments" and "extenders." "Pigments", as thus defined, are chiefly oxides or other compounds of the heavy metals and are characterized by high hiding power and tinting strength, whereas the so-called "extenders" are chiefly nonmetallic mineral additions having little real covering power. Some of the latter are used primarily to cheapen the cost of paint, but they may exert a beneficial influence on the durability as well as working properties, or provide what is known as "tooth", as in the case of silica. The white pigments are by far the most important; they are used not only in white paints but also in virtually all colored paints, most of which derive their color by the addition of small amounts of substances actually having the desired color.

VARIETIES OF WHITE PIGMENTS

The leading white pigments are compounds of lead, zinc, or titanium. In the early days of the paint industry white lead was by far the most important pigment, being universally recognized as the most desirable single ingredient. Early specifications invariably demanded pure white lead and oil when the best results were desired, regardless of cost. Certain oxides of lead - notably litharge, massicot, and red lead - have been used in paints and are still used to some extent. The principal lead pigment, however, is white lead, an artificially prepared mixture of carbonate and hydroxide of lead. Native lead carbonate was used by the Greeks and Romans as a paint pigment and Pliny mentions the manufacture of artificial white lead with metallic lead and vinegar. A similar process was also described by Theophrastus in 300 B.C. and by the beginning of the Christian era the white lead industry seems to have reached substantial proportions, especially at Rhodes. Following the fall of the Roman Empire the manufacture of this pigment apparently ceased until re-established in Holland where it seems to have been in flourishing condition by 1622. The Dutch process is the original and still the most largely used method of manufacturing white lead, but it is extremely slow, requiring about 3 months to complete; consequently various quick processes have been devised, some of which produce an equally good product. So-called "Sublimed white lead" is an entirely different material; it is a basic sulphate rather than a basic carbonate and may be made from lead ore as well as from the metal. White lead has good hiding power and great durability and is used extensively, alone or in substantial mixtures, for outdoor painting. Red lead is used in protective paints for structural steel.

The important zinc pigments are zinc oxide, leaded zinc oxide, and lithopone. French-process zinc oxides are made by distilling slab zinc and allowing the fumes to oxidize in the air. American-process lead-free zinc oxides, on the other hand, are made directly from zinc ore and therefore are often referred to as "direct-process oxides." Leaded zinc oxides carrying 5 to 50 percent lead in the form of lead sulphate are likewise direct- or American-process oxides but are made from ores containing more or less lead in addition to zinc. Lithopone is a mixture of zinc sulphide and barium sulphate prepared by double precipitation, starting with zinc sulphate and barium sulphide solutions.

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Zinc pigments came into use much later than white lead. The first great impetus to the industry was the invention in 1854 of the American process for making zinc oxide direct from the ore. Before that year French-process oxides were produced on only a small scale. There is abundant evidence that sales of zinc oxides advanced rapidly during the next half century, but because of the prominence in the field of one large producer statistics of production were not published for many years. As recently as 1910, however, sales of lead pigments in the United States were still fully twice as large as sales of zinc oxides and more than 10 times as large as those of lithopone. Lithopone, in fact, is rather a newcomer in the field of white pigments. The first lithopone plant in the United States was built by the Beckton Chemical Co. at 272 Passaic Street, Newark, N.J., in 1892, and 4 years later a second plant was built on the land of Harrison Bros. & Co., Philadelphia. In the year 1900, these two companies produced 920 tons. Krebs Pigment & Chemical Co. erected at Newport, Del., a lithopone plant designed to produce 5 tons daily in 1901 and about the same time the Grasselli Chemical Co. and the N. Z. Graves Co. also entered the field. By 1906, when regular production statistics were first recorded, the output had risen to 4,300 tons, and even before the outbreak of the World War it was growing rapidly; later it increased at an astonishing rate. From 1923 to 1928 the domestic output of lithopone doubled and by 1926 had outstripped the output of white lead, as well as of zinc oxides, which meanwhile had continued to win business from its long-established competitor, white lead. Lithopone, even more than zinc oxide, is used in the paint industry chiefly for interior work. Zinc oxide in oil and pigment mixtures of practical brushing consistency has less covering power than white lead and suffers from its rather high oil absorption, but it has several advantages beyond the fact that it is nonpoisonous and is not darkened by sulphur gases.

The latest white pigments to come into extensive use were the titanium group. As long ago as 1870 Dr. J. Overton introduced titanium compounds as pigments, using a mixture of rutile with the vehicle as a resistant paint on ships' bottoms. J. W. Rylands, a Birmingham (England) varnishmaker, obtained a cargo lot of ilmenite from the Norwegian mines of a company that went into liquidation in 1869; he, perhaps, was the first to use titanium for paint-pigment purposes, but his idea was to use the powdered ilmenite as a black pigment. About the same time Overton in the United States employed ground rutile in a bituminous composition. In 1908 the Norwegian Government began experiments to discover a method of extracting titanium from its ores and to find major uses for the element. However, the real history of commercial titanium pigments probably began in the laboratory of Dr. A. J. Rossi, whose earlier work on titanium-bearing ores had led gradually to the commercial manufacture of titanium alloys in 1906. Continuing his experiments, Dr. Rossi succeeded in making an impure oxide, and in 1908 he demonstrated the opacity of the material and thus glimpsed its suitability as a paint pigment. About 1910 research into suitable methods for producing titanium white was stimulated by legislation in Europe directed against the use of white lead, and finally the experimenters in America and Europe, combining their resources, adopted a standard method of extracting titanium oxide from ilmenite with sulphuric acid. Associated with Doctor Rossi in the United States was L. E. Barton and the concurrent discoveries in Norway were made by Gustav Jebsen, V. M. Goldschmidt, and J. P. Yeager.

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GROWTH OF TITANIUM-PIGMENT INDUSTRY

In 1916 the Titanium Pigment Co. was incorporated and began to build a factory adjoining the works of the Titanium Alloy Manufacturing Co. at Niagara Falls, N.Y. Operation of this factory was delayed until after the armistice in 1918, when commercial production was begun. The National Lead Co. purchased a substantial interest in the new enterprise in 1920; by 1922 domestic demand exceeded the limited capacity of the Niagara Falls factory, and titanium pigments were imported from Europe. A second and larger factory was built in St. Louis during 1923. At first the only titanium pigment produced was the barium-base grade now known as Titanox B. Production of calcium-base pigments (Titanox C) was begun at Niagara Falls in 1925, but in 1928 this work was transferred to St. Louis where hitherto only barium-base pigment had been produced. For a time the Niagara Falls plant concentrated on the production of pure titanium dioxide (Titanox A), but later this operation too was transfered to St. Louis. In 1928 the Commercial Pigments Co. began operation in Baltimore. The pioneer manufacturer in Europe was the Titan Company A/S, Frederikstad, Norway. In 1927 it was reported that the National Lead Co. had entered into a cooperative agreement with the Titan Co. and had bought the majority of the shares of the Norwegian company; that it controlled the Ste. Industriell du Titan, France, originally a French-Norwegian concern; and that the German Dye Trust (I.G. Farbenindustrie) had also entered into the combine. Plants were constructed in other foreign countries, and productive capacity in the United States increased rapidly.

SALES DATA

As previously noted, the demand for white pigments, although well-sustaine when compared with the demand for many other commodities, dropped rather seriously during the depression. Sales of titanium pigments, on the other hand, continued to grow rapidly, countercurrent to the general trend. While sales of white lead declined almost 60 percent from 1927 to their low point in 1932, sales of titanium pigments during the same period much more than doubled. Zinc oxides sales also declined but not quite so markedly as those of white lead, and sales of lithopone dropped only a little over 30 percent during the period. However, it should be noted that from 1927 to 1929 the gradual displacement of white lead by zinc oxides and lithopone apparently was still in progress. Whereas sales of these zinc pigments reached their maximum in 1929, sales of white lead reached their highest point in 1922.

Figure 1 shows the trend of sales of white lead, zinc oxide, lithopone, and titanium pigments in the United States in terms of index numbers, the 1929 sales representing 100 percent. Inasmuch as the tonnage sales of titanium pigments, even as late as 1929, were relatively small, the percentage figures tend to exaggerate the relative importance of these pigments as regards actual consumption. The chart, however, does show the relative movement of sales tonnages of other leading white pigments. For example, sales of zinc oxide follow closely the ups and downs of general industrial activity as measured by the Federal Reserve Board index of production - at least until 1934 when they dropped unexpectedly. After reaching a peak in 1922, sales of white lead dropped gradually until 1929, whereas sales of other white pigments as

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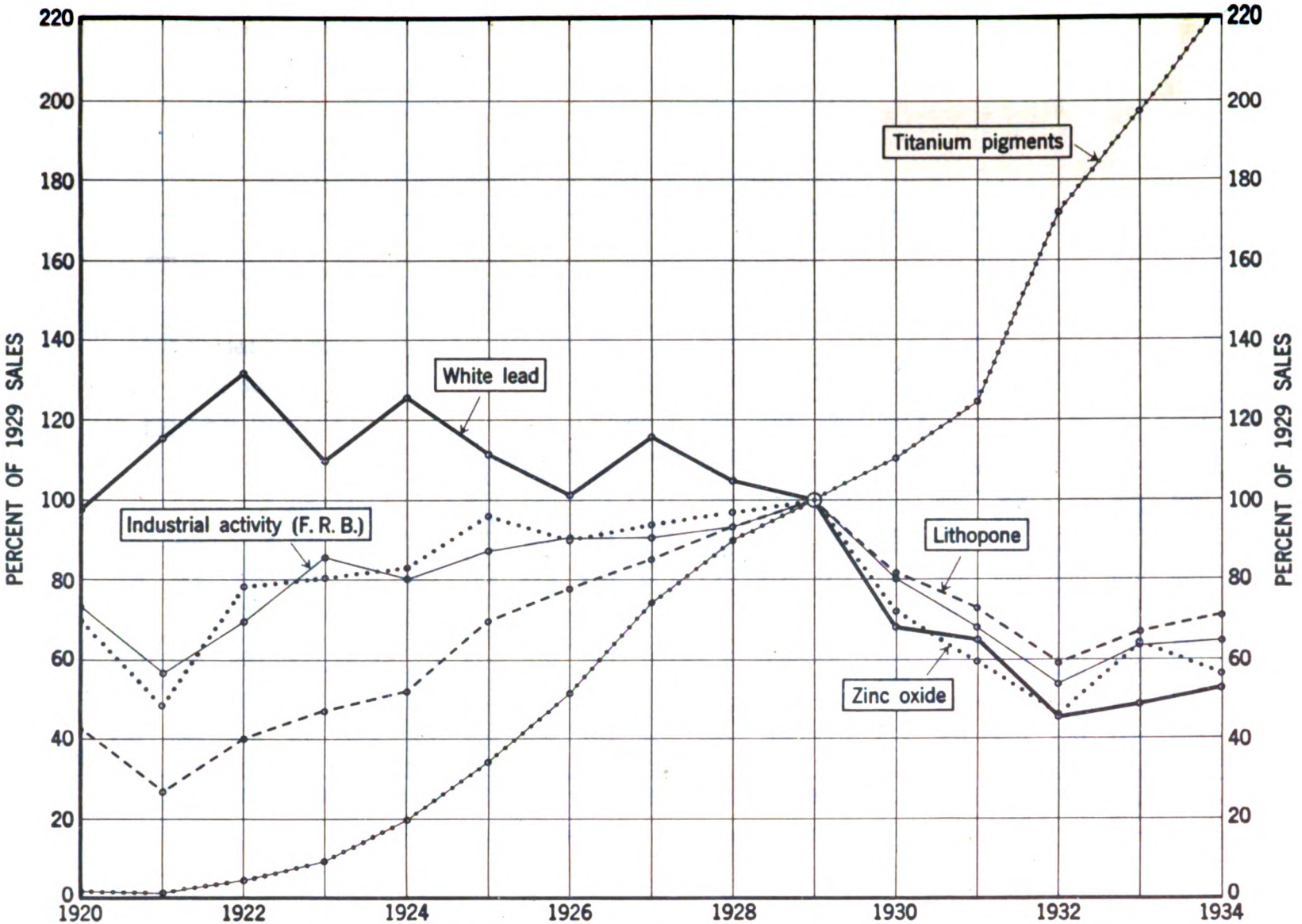

Figure 1.—Sales of white lead, zinc oxide, lithopone, and titanium pigments in the United States, 1920–34.
(Index numbers, 1929=100.)

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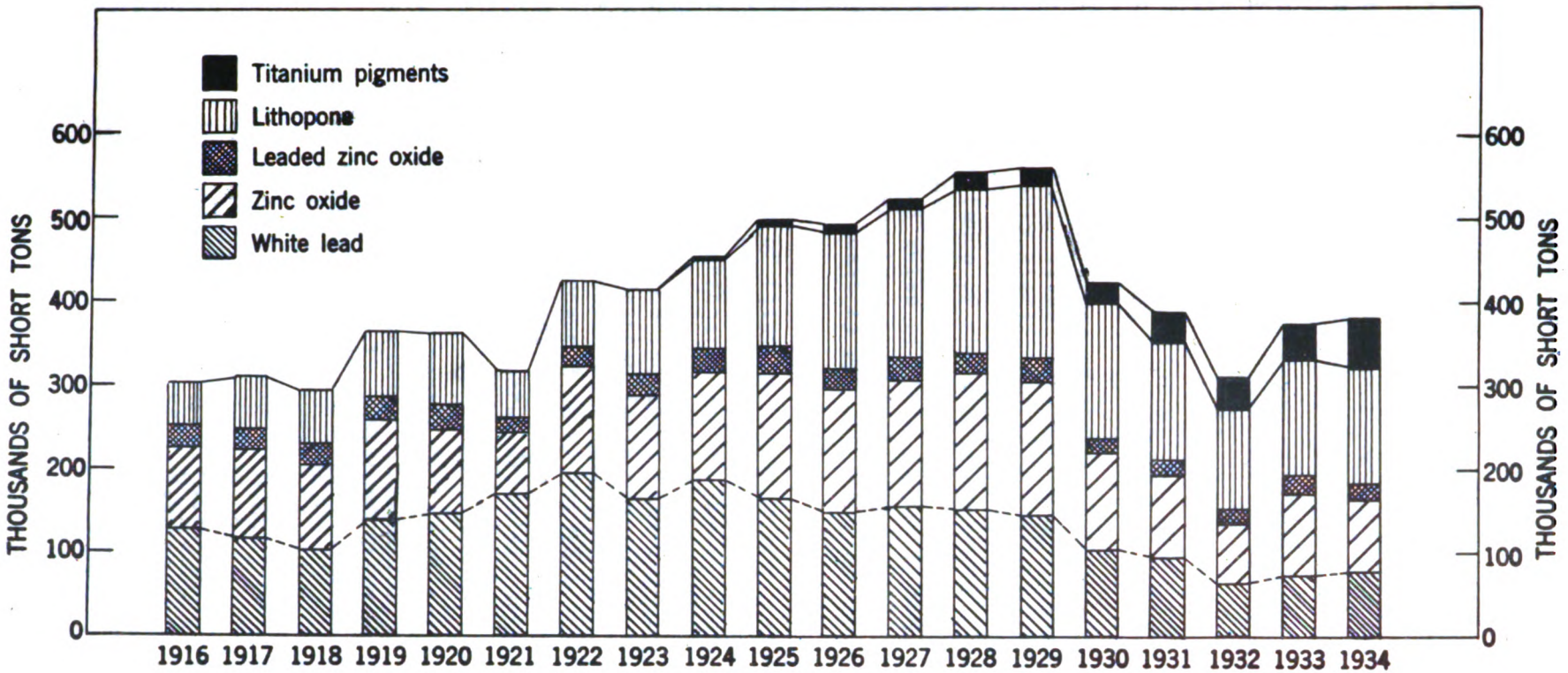

Figure 2.—Domestic sales of white pigments, 1916–34.

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well as general business activity kept on advancing. After 1929 sales of white lead, although continuing their decline, began to keep step with sales of zinc oxides. Both classes of pigments, however, dropped a little behind the procession; they were more or less in balance with each other, but they failed to get their share of business in competition.

Lithopone sales, which hitherto had risen at the rate of almost 10 percent a year, declined in 1929, but after 1930 they exhibited a slightly more favorable trend than general business activity.

By comparison with other barometers the uninterrupted, sharp uptrend in the sales of titanium pigments (fig. 1) is all the more spectacular.

Firure 2 compares the leading types of white pigments on the basis of actual tonnages sold. Apparently titanium pigments, although growing rapidly, did not constitute a particularly significant proportion of aggregate pigment sales until after 1929, when the shrinkage in sales of lead and zinc pigments served to accentuate the importance of the expanding sales of the titanium group. In 1929 sales of titanium pigments probably constituted considerably less than 5 percent of the total sales of white pigments; but in 1932 - the low point for lead and zinc pigments - they represented well over 10 percent, and in 1934 they constituted at least 13 percent and possibly a considerably higher percentage of the total.

No statistics on production of titanium pigments are available, and accordingly the figures used in this paper are estimates. Inasmuch as titamium-pigment factories on the Atlantic seaboard, at St. Louis, and at Niagara Falls all obtain their raw material from overseas, the imports of ilmenite afford a rough index of the recent growth of the industry. The imports, it may be noted, have been almost wholly from British India, except in some of the earlier years, notably 1926-30, when some thousands of tons came from Senegal and Brazil, and in 1935, when imports were resumed on an expanded scale from Norway, which accounted for 22,000 tons or almost one fourth of the total receipts during the first 9 months of the current year. Official figures for imports of ilmenite for recent years follow:

Imports of ilmenite for consumption in the United States, 1929-35

Year	Long tons	Average value per ton 1/	Quantity index 2/
1929	22,386	$4.68	100
1930	22,297	6.75	99
1931	29,857	4.85	133
1932	33,491	6.92	150
1933	38,610	5.08	172
1934	71,710	4.97	320
1935	115,871	5.50	517

1/ Nominally f.o.b. foreign mines. 2/ In percent of 1929 tonnage.

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Canadian experience affords a further index of trends in this country. Consumption of titanium white in the Canadian paint industry, as reported by the Dominion Bureau of Statistics, more than doubled in 3 years. The figures follow:

Consumption of titanium white in Canadian paint industry

Year	Pounds	Cost at works
1931	745,207	$89,761
1932	691,304	96,759
1933	1,061,249	128,969
1934	1,710,188	186,678

Although the consumption of titanium dioxide for the manufacture of pigments can be closely approximated from the ilmenite import figures, there is the chance of a large error in estimating the aggregate sales of all grades of titanium pigments even after allowance has been made for fluctuations in stocks. Less than half of the total sales are sales of the pure dioxide, the balance being made up largely of titanium-calcium pigment. A leading brand of titanium-calcium pigment contains 30 percent TiO_2 "precipitated upon and coalesced with calcium sulphate," and the standard titanium-barium pigments contain 25 percent TiO_2 with blanc fixe making up the balance. Titanated lithopones generally contain 15 percent TiO_2. In the early years of the industry the bulk of the production was the barium-base pigment, but since about 1928 the proportion of pure dioxide has increased and calcium-base pigments are now a more important product than the barium-base type. At present probably at least 80 percent - and for some years an even larger proportion - of the titanium-pigment sales has consisted of these composite pigments; to add to the confusion of the statistician lead titanate has appeared on the market. However, this product, which is not a white pigment, was not produced commercially until 1935. A new titanium silicate base pigment for use in outside paints has also been introduced recently.

The estimates of titanium-pigment sales given herein probably are conservative. Instead of 50,000 tons for 1934, several authorities in touch with market conditions consider that as much as 75,000 tons may have been marketed. The larger figure could be accounted for readily by the large increase in imports of ilmenite in 1934 - the only assumption being that a larger fraction of the raw material was used for current production instead of being stored as reserve supplies at the several plants under construction. This estimate, if correct, would indicate a far more rapid encroachment of these new products upon the strongholds of their competitors. Of greater significance, however, is the phenomenal expansion of productive capacity which, beginning late in 1934, has at least doubled the potential production of titanium pigments. This foreshadows expansion in titanium-pigment sales at a probably accelerated pace during 1935.

Undoubtedly part of the anticipated increase in titanium-pigment sales will be absorbed by increased demand for pigments of all kinds; nevertheless, displacement of other white pigments necessarily will continue. The statistical evidence is clear even though the causes therefor may be questioned.

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It is not the purpose of this paper to discuss the relative merits of the various white pigments. In fact, recognized experts are not fully in accord on this subject because, notwithstanding years of research, no satisfactory laboratory technic has yet been developed for evaluating a paint accurately in respect to its employment under all conditions of practical use. The sales figures show noticeable displacement of white lead by other pigments, but careful study of the trends indicates that substitution of other pigments for white lead already has reached a balance and may actually have proceeded too far. In any event, many of those in the paint trade feel that white lead, zinc oxide, and lithopone really are not in severe competition with one another, each having its own legitimate field which it can dominate by virtue of price or inherent physical qualities. Some authorities forecast further contraction in sales of zinc oxides, at least relatively in respect to total pigment sales, but apparently the main repercussion of probable further increases in consumption of titanium pigments will fall upon lithopone. Statistics show quite clearly that the large expansion in lithopone sales to the paint trade is attributable almost exclusively to the simultaneous expansion in demand for interior paint, notably flat wall paints. In this field titanium pigments are recognized as a formidable competitor; many experts, in fact, contend that they are greatly superior to lithopone owing to their greater hiding power. There also seems to be opportunity for a considerable use of titanium pigments in outside paints for which lithopone theoretically is not so well-adapted owing to its chemical composition.

DISTRIBUTION OF PIGMENT CONSUMPTION BY INDUSTRIES

It should be remembered that zinc pigments, as well as lead pigments, do not depend wholly upon the paint trade for their market. Sales of lead and zinc pigments by uses, as reported by producers to the Bureau of Mines, are shown in the table on page 12.

The importance of the rubber industry, particularly with respect to zinc oxide, is clearly shown and there seems to be no tendency to displace zinc pigments in the rubber industry by titanium pigments. Although titanium compounds are finding their way into floor coverings and textiles and to a limited extent even into rubber goods, their function in these articles is solely that of an inert pigment, whereas zinc compounds, particularly in rubber, have other beneficial effects when used in proper balance with other constituents of the batch. Even in paints the hardening effect of zinc oxide guarantees its continued use in suitable proportions for certain classes of paints, while the oxidizing or drying action of white lead, combined with its other valuable properties, assures its continued use as a major constituent of most types of good paint, especially exterior paints.

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Sales of lead and zinc pigments, by uses, 1931-34

Pigment	1931		1932		1933		1934	
	Short tons	Percent 1/	Short tons	Percent 1/	Short tons	Percent 1/	Short tons	Percent 1/
White lead (dry and in oil):								
Paints	91,832	94.3	63,399	95.1	68,368	93.7	75,008	95.3
Ceramics	2,848	2.9	1,761	2.6	1,617	2.2	1,434	1.8
Other	2,688	2.8	1,514	2.3	2,997	4.1	2,292	2.9
	97,368	100.0	66,674	100.0	72,982	100.0	78,734	100.0
Basic lead sulphate:								
Paints	8,311	85.8	5,689	90.9	7,072	89.0	6,611	93.5
Batteries	697	7.2	195	3.1	99	1.3	139	2.0
Rubber	173	1.8	77	1.2	161	2.0	93	1.3
Other	505	5.2	296	4.8	613	7.7	224	3.2
	9,686	100.0	6,257	100.0	7,945	100.0	7,067	100.0
Zinc oxide:								
Rubber	47,972	50.1	37,679	52.1	53,869	54.7	50,145	57.6
Paints	31,357	32.8	22,369	31.0	29,218	29.7	23,741	27.3
Floor coverings and textiles	4,695	4.9	2,837	3.9	4,087	4.1	4,781	5.5
Ceramics	3,171	3.3	1,782	2.5	2,639	2.7	2,963	3.4
Other	8,505	8.9	7,583	10.5	8,729	8.8	5,458	6.2
	95,700	100.0	72,250	100.0	98,542	100.0	87,088	100.0
Leaded zinc oxide:								
Paints	18,292	98.5	14,072	98.4	22,488	98.3	20,376	99.4
Rubber	38	.2	26	.2	46	.2	28	.1
Other	247	1.3	207	1.4	334	1.5	102	.5
	18,577	100.0	14,305	100.0	22,868	100.0	20,506	100.0
Lithopone:								
Paints, etc.	119,446	78.7	93,465	76.8	106,995	76.0	114,472	78.6
Floor coverings and textiles	20,780	13.7	17,601	14.5	18,472	13.1	14,811	10.2
Rubber	5,833	3.8	3,955	3.2	5,078	3.6	4,596	3.2
Other	5,791	3.8	6,646	5.5	10,286	7.3	11,686	8.0
	151,850	100.0	121,667	100.0	140,831	100.0	145,565	100.0

1/Percent of total annual sales of each pigment.

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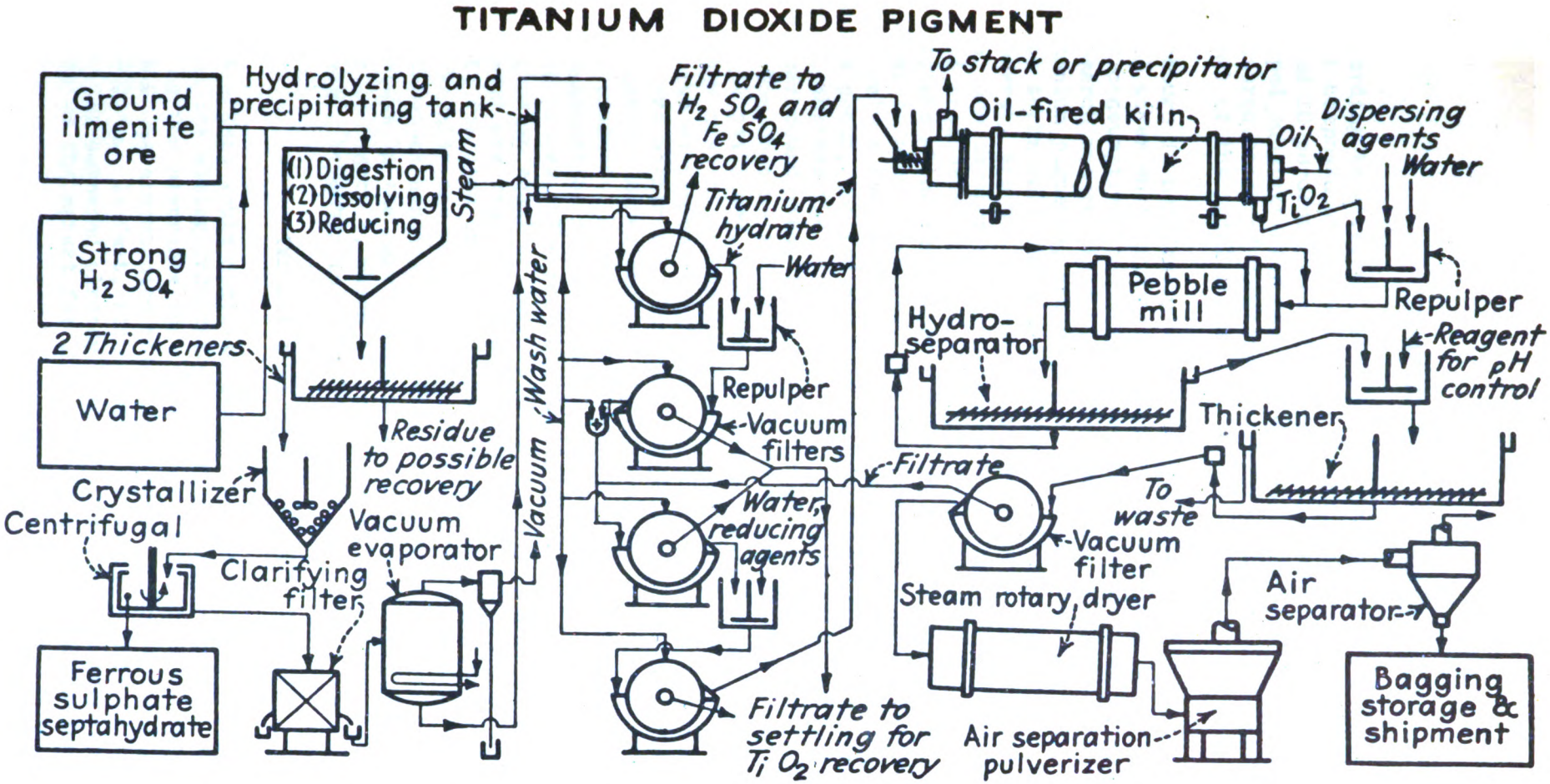

Figure 3.- Flow sheet of titanium-dioxide-pigment manufacturing process (from Chemical and Metallurgical Engineering).

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CHEAP TITANIUM RAW MATERIALS

According to a recent estimate the typical outside paint formerly carried a pigment composed of approximately 60 percent white lead, 30 percent zinc oxide, and 10 percent "inerts", whereas at present the ratio of white lead has dropped substantially and that of zinc oxide and inerts slightly, owing to the introduction of composite titanium pigments in proportions up to about 30 percent of the total solids.

Although it manifestly will be impossible for titanium pigments to displace all other white pigments in paint manufacture, any more than they can in other consumptive industries, the premium on this displacement is high. Much research was required to develop suitable processes for making satisfactory titanium pigments, and even now the methods of production demand considerable technical skill and experience. The various processes of manufacture, however, are not fundamentally costly, and the raw materials, notably ilmenite, are cheaper and undoubtedly will continue to be very much cheaper than lead ores or zinc ores. Foreign ilmenite is being delivered at consuming points along the Atlantic seaboard for well under $10 per long ton, equivalent to around 3/4 cent per pound of recoverable titanium dioxide contained. Only a few years ago titanium dioxide for pigment use cost 50 cents or more a pound, but for the last several years the price has been held at 17 cents, whereas the barium-base and calcium-base pigments have remained at 6 cents per pound since 1933. These prices evidently have promoted sales, so there has been no inducement to reduce them further. Moreover, the titanium industry is still new, and overhead costs undoubtedly continue high because of the high cost of research and experimentation, both into factory processes and into the economical utilization of the product. Installation costs, likewise, are higher for plants making titanium pigments than for other white pigment plants. Experience in the case of all successfully merchandised technical products, however, has demonstrated beyond all doubt that prices drop as consumption rises as well as that increased consumption is consequent upon lower prices. The rock-bottom raw-material cost of 3/4 cent for titanium dioxide plus an equal or only slightly greater charge for sulphur (up to 1-1/2 tons of acid are required to decompose 1 ton of ilmenite) compares with 2-1/2 to 5 cents for zinc oxide and 3 to 4 cents for white lead. Even if one discounts liberally the additional cost of converting ore to pigment, the fundamental-cost handicap in favor of titanium pigments is overwhelming. Essential steps in the manufacture of titanium dioxide pigment are shown diagrammatically in figure 3, which is reproduced from Chemical and Metallurgical Engineering. (November 1935, p. 595).

IMPLICATIONS TO THE MINING INDUSTRY

What effect would diminished sales of lead and zinc pigments have upon the respective mining industries? This is a bold question and should be tempered by the assurance that there is no likelihood of any such drastic readjustment as accompanied the displacement of horse-and-buggy by automobile transportation. In fact, with respect to white lead it is quite likely that the worst has happened already, and it is not at all certain that further encroachment on the market for zinc will follow the increasing use of titanium white.

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Further encroachment, however, is of concern to the American mining industry as a whole because, under present conditions, domestic mines furnish relatively small quantities of ilmenite, one of the principal raw materials for titanium pigments. Very large reserves of titanium-bearing ores undoubtedly exist in the United States, but it is significant that the areas containing the largest number of deposits have been examined repeatedly by leading consumers who, nevertheless, continue to draw their supplies from abroad. Sulphur, the other leading raw material for titanium pigment-making, is dominantly an American product, as is lime, whereas barite (for composite pigments) is produced here and is also imported.

In 1929, according to figures supplied by producers to the Bureau of Mines, white pigments accounted for about 135,000 tons of lead (in white lead and lead sulphate only), 190,000 tons of zinc, and large tonnages of barite, of which 223,188 tons were used in the manufacture of lithopone alone. In 1932, the recent low year, the white-pigment industry consumed 58,720 tons of lead, 86,455 tons of zinc, and around 150,000 tons of barite. Consequently, in terms of total domestic consumption the white-pigment industry afforded an outlet for approximately 15 percent of the lead, 35 percent of the zinc, and over 75 percent of the barite used in the United States in a boom year and around 15 percent of the lead, 25 percent of the zinc, and 80 percent of the barite consumption in the depression year 1932. Obviously, the barite industry has a major stake in this field; titanium-barium pigments are holding their own for exterior paints but titanium-calcium pigments are relatively more important due to their employment in interior paints. Also, the zinc industry leans more heavily upon the pigments market than the lead industry which has many other sources of support.

Secondary materials and ore are employed as raw materials for producing basic lead sulphate in only relatively small amounts; all the white lead and latterly most of the sulphate is manufactured from pig lead. Slab zinc, on the other hand, is not the main source of zinc pigments; in fact, it is not used at all in making lithopone. Sources of zinc consumed in making specified pigments are shown in the following table:

Zinc content of zinc pigments and salts produced by domestic manufacturers, 1933-34, by sources, in short tons

Pigment or salt	1933				1934			
	Zinc in pigments and salts produced from -			Total zinc in pigments and salts	Zinc in pigments and salts produced from -			Total zinc in pigments and salts
	Domestic ore	Slab zinc	Secondary material		Domestic ore	Slab zinc	Secondary material	
Zinc oxide	42,110	32,784	2,848	77,742	42,460	25,371	2,594	70,425
Leaded zinc oxide	10,913	31	118	11,062	11,478	---	95	11,573
Lithopone	1/17,749	---	11,288	1/29,037	1/20,519	---	10,836	1/31,355
Zinc chloride	---	101	6,680	6,781	---	19	4,216	4,235
Zinc sulphate	850	---	864	1,714	1,530	1	411	1,942
	71,622	32,916	21,798	126,336	75,987	25,391	18,152	119,530

1/ Includes zinc content of a small quantity of zinc sulphide produced.

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The foregoing table indicates that even if the zinc industry does lose markets in the pigment field the blow will not fall heavily upon the smelters or electrolytic refineries, except possibly insofar as they might be affected indirectly by the all-round shrinkage in demand for zinc from both secondary and primary sources. To offset this, research in the fields of zinc salts and a normal expansion in the zinc requirements of industry in general apparently would solve the problem to the satisfaction of all concerned, except perhaps the lithopone makers; several of the largest of these, however, are already in the titanium-pigment business.

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